सत्यमेव जयते

(GOVERNMENT OF INDIA)

(MINISTRY OF RAILWAYS)

(For official use only)

A Report on Bench marking Study of CTRB (Class "E") Repair Facilities



CAMTECH/2019/M4/W/CTRB.Repir*.*

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अअमा सं RDS

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EXCELLENCE IN MAINTENANCE

Indian Railways

Centre for Advanced Maintenance Technology

Maharajpur, Gwalior –474005(INDIA)

Ph:0751 -2470803 & Fax: 0751 -2470841

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Abbreviation

COE	Centre of Excellence
CTRB	Cartridge Taper Roller Bearing
E & R	Efficiency & Research
ID	Internal Diameter
IR	Indian Railway
LED	Light Emitting Diode
OD	Outer Diameter
OEM	Original Equipment Manufacturer
PLC	Programmable Logic Controller

Preface

Cartridge Taper Roller Bearings (CTRB) play vital role on safety and reliability of Rolling Stock. Class"E" CTRB were initially introduced on IR with newly designed freight stock with Air brake system ie BOXN/BCN type of wagons. Initially CTRB were imported and later on indigenised by TIMKEN India and NBC/NEI. CTRB maintenance facilities were set up in Railway Workshops in accordance with OEM maintenance instructions available at that time. RDSO issued instructions to attend CTRB vide G-81Maintenance manual for CTRB.

With the advancement in manufacturing and repair technology, CTRB maintenance standards have since evolved to provide higher level of performance and reliability. This is achieved by carrying out specialised component level repair/rehabilitation and ensuring higher geometrical accuracies. Specialised Bearing Refurbishment facilities having requisite machinery and process have been set up by bearing OEMs in India M/s Timken & M/s NEI.

Railway Board vide letter No. 2018/M(N)/951/35 (dated 04.02.2019) advised RDSO to prepare a report on facility and practices being followed for each activity or roller bearing overhaul by railway workshops and OEMs.

This report comprises of maintenance procedures and M&Ps that is being used by Indian Railway and OEMs during the maintenance and refurbishment of CTRB. The information provided herewith will help in identifying the kind of M&P and maintenance practices required for CTRB refurbishment so that additional inputs required in Railway Workshops can be identified and planned.

Date: 31.12.2019
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(Manoj Kumar)
Jt. Director/Mechanical
CAMTECH/Gwalior

1. Background

To counter the effect of reduced fatigue life due to increased load, bearings have undergone to evolutionary change. For fitment to the BOXN Wagons designed by the RDSO, Cartridge Taper Roller Bearing (CTRB) were introduced in the year of 1984. These bearings are grease packed and require no field lubrication.

The bearing 'Class E' (6" x 11") cartridge tapered roller bearing, often referred to as a packaged bearing. Packaged bearings consist of two tapered roller bearing assemblies (sometimes referred to as cones and includes the inner ring, rollers and cage) mounted inside a common outer ring (sometimes referred to as the cup). Between the two bearing assemblies is a spacer ring of specific width so as to correctly.

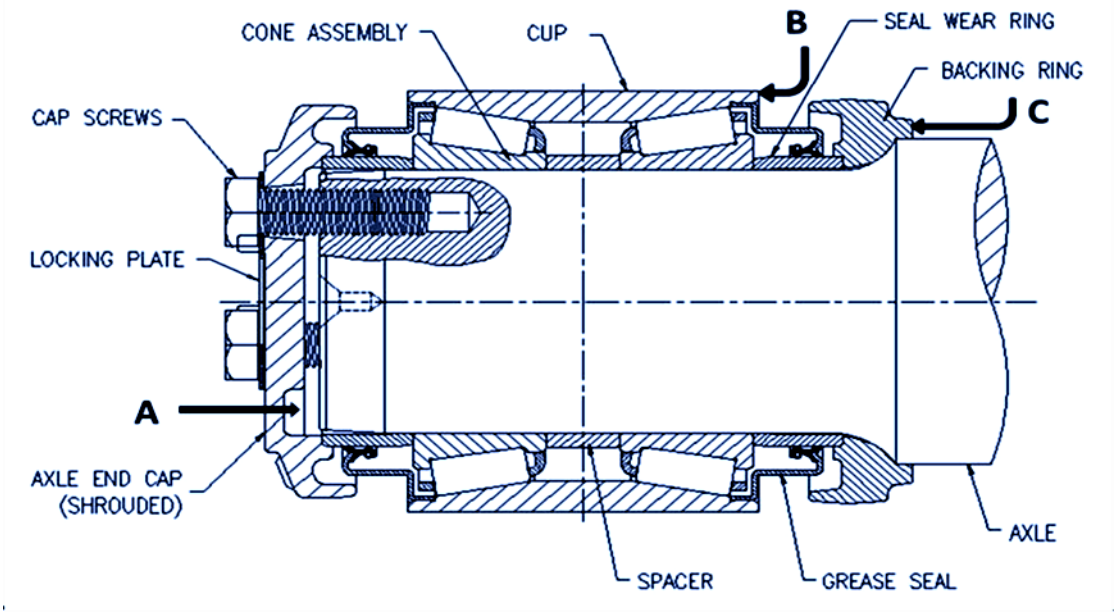


Fig1: CTRB class E

2. Purpose of Report

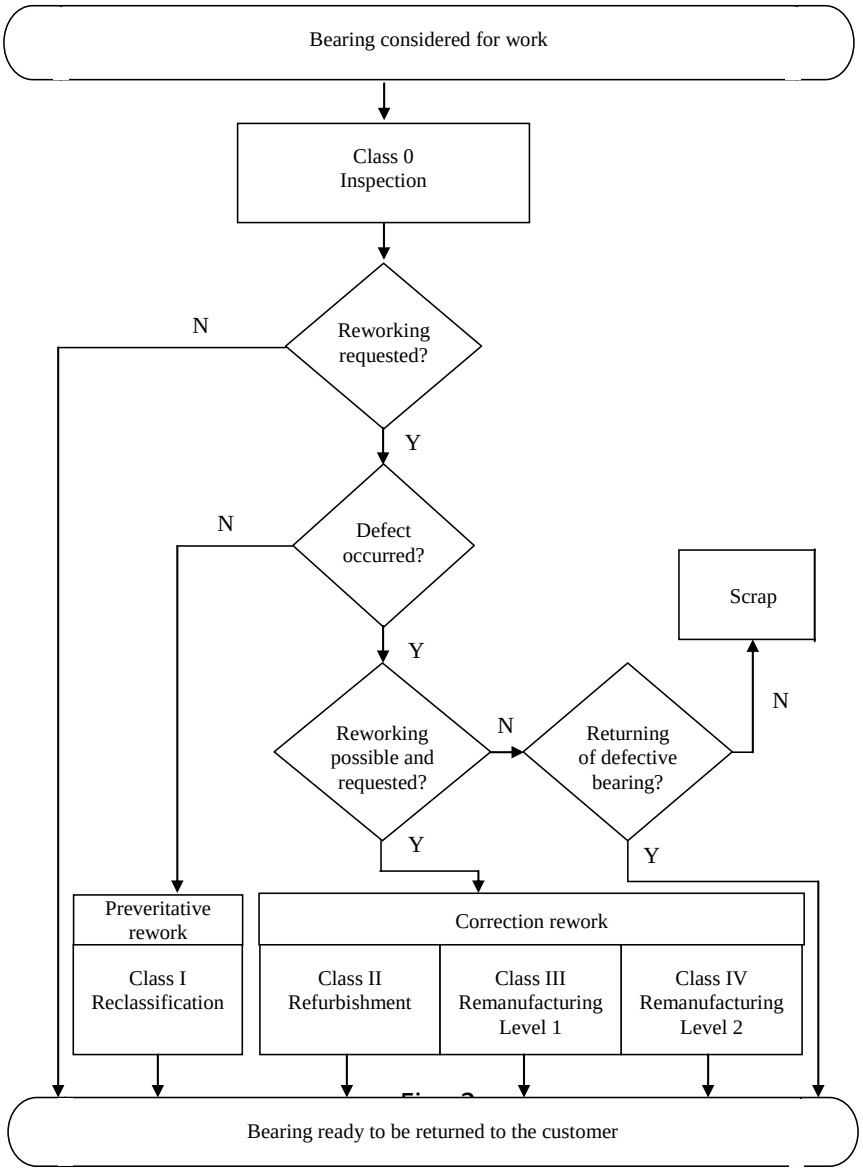
Purpose of this report is to compare the maintenance practice of CTRB at Railway Workshops and reconditioning practices followed by OEMs. This report will help to identify the process and facility difference of OEM (M/s Timken & M/s NEI) and Railway workshops. So that existing system can be upgraded to improve safety and reliability of bearings. Maintenance manual of CTRB (G-81) for Class-E is based on the information provided by OEMs.

3. Terms of Reference

Railway Board vide letter No. 2018/M(N)/951/35 (dated 04.02.2019) advised RDSO to prepare a report of M&Ps and practices being followed for each activity by individual workshops and OEMs during refurbishment of CTRBs.

4. Bearing Rework Process

According to the rate of prior use and the wear status, bearing rework can be divided into five classes (fig. 2).



OEM such as SKF, NEI and TIMKEN carry out bearing rework into five classes. While the operations in the particular classes are numbered, the actual sequence of the work is not directly related to these numbers. Special agreements between the maintenance company and the operator must be respected.

4.1 Class 0 – Inspection.

Class-0 Inspection includes inspecting used bearings (or bearings stored for a long time) and comparing them with drawing/specification requirements. This process involves:

1. Cleaning.
2. Non-destructive testing.
3. Visual/microscopic inspection.
4. Dimensional inspection.
5. Providing a report.

Note: Usually a recommendation for appropriate treatment and suitable rework is given.

4.2 Class I – Reclassification (re-qualifying, reclamation).

Reclassification includes all operations of inspection (Class 0) and the following additional work:

1. Minor repair: buffing and minor polishing of inactive and active surfaces, grinding of scratches and grooves.
2. Demagnetization.
3. Reassembly (including cage riveting if necessary).
4. Dynamic testing (if required): bearing ring rotation to evaluate noise levels, determine torque characteristics and/or similar functional parameters.
5. Lubrication/preservation.
6. Packaging.

4.3 Class II – Refurbishment (reconditioning).

Refurbishment of bearings encompasses all operations of inspection (Class 0) and reclassification (Class I) plus one or more of the following:

1. Replacing rolling elements if necessary, installing oversize rolling elements (of the same nominal diameter (see further work).
2. Remanufacturing the cage or replacing it with an identical cage.
3. Interchanging used components (e.g., seals, snap rings ,etc.).
4. Grinding or polishing and/or plating mounting surfaces as necessary to return to original drawing dimensions of the bearing outside surface and bore.

5. Polishing raceways (not to exceed 13 µm total metal removals per surface).

4.4 Class III – Remanufacturing level 1.

Remanufacturing level 1 for bearings encompasses all previous operations of inspection (Class 0) and reclassification (Class I) and, where appropriate, refurbishment operations (Class II) plus one or more of the following operations:

1. Grinding raceways – up to 75 µm per surface and if the outside diameter, D> 400 mm, up to 300 µm.
2. Installing oversize rolling elements of a larger nominal diameter (see operation 13).
3. Installing the original reworked cage or a new one (see operation 14).
4. Changing or substituting components to create a different assembly identity (tuning: modifying in order to improve performance or properties).

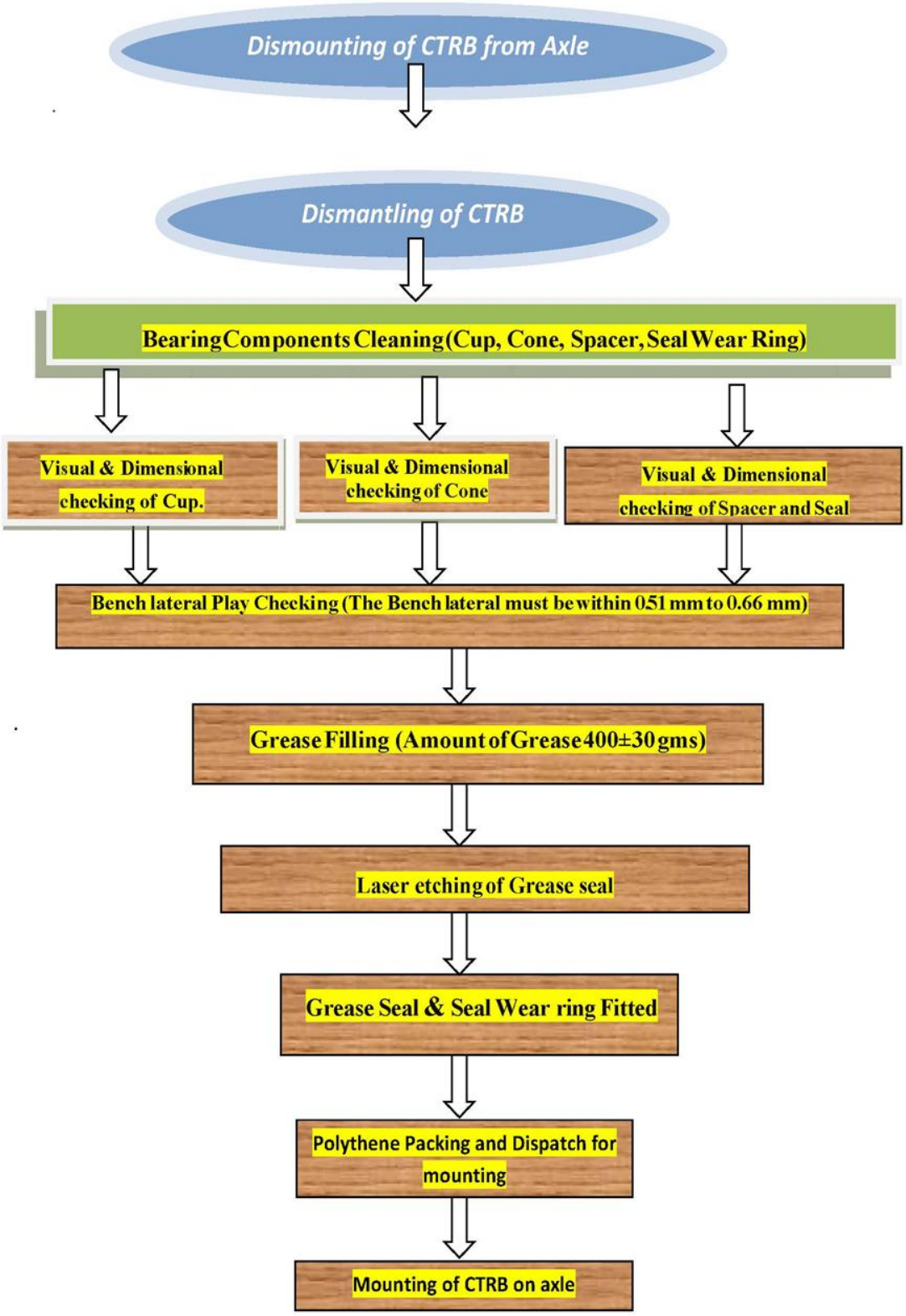
4.5 Class IV – Remanufacturing level 2.

Remanufacturing level 2 for bearings involves reworking bearings of Classes I to III plus an additional operation:

1. Installing a new ring.

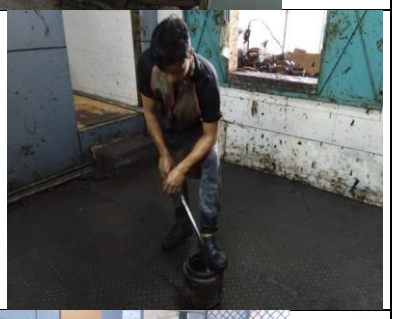
5. Maintenance Procedure of CTRB in Railway Workshops

Maintenance Procedure followed by Workshops on Indian Railways is shown below.



Maintenance Procedure of CTRB in Railway Workshops

6. CTRB Maintenance in various Railway Workshops.

Workstation &Area wise Activities	Photograph
Workstation 1 **CTRB Receiving** CTRBs are taken to the dismantling area from CTRB extraction area through transfer window and conveyer.	
Workstation 2 **CTRB dismantling** By prey bar By hydraulic press	
Workstation 3 **Cone Soaking** Cones of CTRB are soaked in kerosene with overnight for efficient grease removal.	
Workstation 4 **Cone Grease Purging** Grease of CTRB cones is purged by using purging machine.	
Workstation 5 **Cone Grease Loosening** Grease Loosening of CTRB cones by using grease loosening machine. Kerosene as a cleaning media K oil is filtered everyday by using in house built kerosene filter plant.	
Workstation 6 **Cone Pre Lubrication** Pre lubrication of CTRB cones to prevent rusting of cones**.**	

Workstation 7 **Cup Cleaning** CTRB cups are cleaned by cup cleaning machine. K oil is the media; filtered everyday by K oil filter plant	
Workstation 8 **Cup Inspection** Inspection of cups equipped with a. Cup OD checking stand with dial gauge. b. Dial bore gauge for checking cup counter bore.	
Workstation 9 **Cone Inspection** Inspection of cones equipped with a. Illuminated variable speed cone checking stand with magnifying glass. b. Feeler gauge/step gauge for checking gap.	
Workstation 10 **Lateral Play Check** Checking of bench lateral play.	
Workstation 11 **Greasing & Assembly of CTRB** a. Automatic grease filling equipment with cut off for consistent measurement of grease quantity. b. Digital weighing machine for cross checking grease weight after every ten CTRB	
Workstation 12 **Spacer checking** Spacer width and parallelism are checked by height gauge.	

Workstation 13 **Laser engraving** Laser engraving of grease seal with MM- YY-DHD notification	

7. Reconditioning of CTRB by OEM

Comparison of Bearing Repair work /Reconditioning procedure is as under.

Bearing Repair & Reconditioning Services	Class I	Class II	Class III
Clean, disassemble and inspect all components at no charge.	✓	✓	✓
Provide a report including visual observations and dimensional data and an estimate for repair.	✓	✓	✓
Polish all components.	✓		
Polish non-ground surfaces, regrind raceways, and manufacture new rollers.		✓	✓
Clean, modify or replace cages.		✓	✓
Inspect for quality during remanufacturing.		✓	✓
Manufacture replacement components and new rolling elements, reset clearances, reassemble, and repackage.			✓
Conduct final quality inspection.	✓	✓	✓
Mark bearing with repair information, repackage and label as repair.	✓	✓	✓

8. CTRB Reconditioning by OEM (TIMKEN, NEI) Vs CTRB Overhauling by Indian Railway Workshops

Sr.	Process	Railway Workshops	OEM (Timken, NEI)	Remarks
1.	Bearing Dismantling	Use of **pry bar** in some workshops and **use of hydraulic press** is followed as per G-81.  Fig:- Use of pry Bar	Hydraulic press (Manual) and automated hydraulic press in used as per lot quantity of bearings.  Fig:- Hydraulic press at Timken	The pressing out of grease seal and dismantling **should only be done with the use of hydraulic press**, preferably automated to save man hours used for dismantling.
2.	Cone cleaning	In some workshops like JHSW, JUDW, bearing cleaning plant in used for cone cleaning after remaining grease by hand. In other workshops, process of **cone soaking, grease loosening, grease purging, jet cleaning** etc. is done on different works stations.  Fig:- Automated cone cleaning machine  Fig:- Grease Loosening  Fig:- Grease purging	Card board based hand cleaning of grease if first done. Then the whole CTRB set is fed into **PLC based automated system** where sequence wise cleaning is done by dripping components in three tanks of chemicals. The CTRBs are placed in array and made to move up and down. First tank is having heated solution. Timken did not share the chemical composition and the temperature of the tanks. Air jets on the periphery of the tanks assist in cleaning. The CTRBS are cleaned as a set **A huge lot can be cleaned in the predefined time frame of 15-25 minutes** 	The use of this system will lead to **effective and fast cleaning.**
3.	Polishing of	Process not done in any	rocess is done on	Polishing of cup,

Sr.	Process	Railway Workshops	OEM (Timken, NEI)	Remarks
	cup and cone	of the workshop	motorized chuck with **the use of scotch brite** with hand. It is simple mechanism that can easily be developed in-house.  Fig:- Polishing being done on motorized chuck in Timken 	cone and other components is important as this will **reveal grooves and hidden defects** which lead to better visual inspection and measurements of dimensions. The railways should **develop polishing facility.**
4.	Phosphating of cup and cone.	Process not done in any of the workshop	Process of phosphating is done **after visual inspection and measurement.** **P**hosphating is done in a sequence of five tanks which are placed side by side of the cleaning plant. **PLC based sequence** is used. The facility has been developed by Timken. This gives a new life to CTRB components against environmental factors	Phosphating is essential after polishing of components is done. If not done, **rusting of cup** and cones will lead to failure of bearings
5.	Cone and cup pairing as per age profile	Pairing of cup and cone assembly as per G-81 followed in IR workshops where it is mentioned to **match Make and age profile of components**. Stacking of cup and cones done to facilitate pairing.	**No such pairing** is being done in Timken. All the cones that are rejected during inspection are replaced with **new set of rollers, or cage. Cones are also machined if needed.**	There is a clear deviation in process of cup and cone pairing in Indian railways and Timken OEM. This is due to the fact that **OEM dismantles cone assembly into cage, rollers and naked cone**. However, no such

Sr.	Process	Railway Workshops	OEM (Timken, NEI)	Remarks
		 Fig- Cup Stacking done brand and age wise at Dahod Workshop.		process is done in IR railways. The age profile pairing may be studied in detail to conclude **whether pairing should be part of IR workshop practice or not.**
6.	Measurement of cone dimensions and out of roundness.	**Digital air gauges** already present at RYPSW, JUDW, JHSW, Railway workshops measure cone dimensions and out of roundness. Internal diameter is measured for cone. Some workshops are in process of procuring it.  Fig:- Baker air gauge at Jagadhari Workshop	Air gauges are used for measuring dimensions of Internal **diameter and external diameter of naked cone, and spacer**. There are two stations, one for ID and one for OD. The readings are projected on an electronic module and record the readings. If the readings are in the range of pre-defined scale, the dimensions are passed.  Fig:- Baker Gauges Electronic module	The use of digital **electronic air comparator gauges** should be made a **standard practice.** The digital gauges are more **accurate and efficient.** The companies that can be made as approved sources are **Baker Gauges Private limited and Mitutoyo (Japanese Make).** This will decrease the element of human error.
7.	Measurement of cup dimensions.	**Air gauge apparatus** are used in some workshops to measure cup **outer diameter and counter bore of cup**. Some workshops use dial bore gauges to measure it like DHDW, KGPW etc. **Taper is not measured as not mentioned in G81 Manual.**	Separate air gauge is used to measure cup dimensions. Here taper of the cup is also measured digitally and recorded**. Taper on both side of the cup** measured separately along with outer diameter and counter bore diameter of the cup. **Air gauges** of **Baker Make** are used for Cup measurement ID, OD, Taper on three stations.	The use of digital electronic air comparator gauges should be made a standard practice. The digital gauges are more accurate and efficient. The companies that can be made as approved sources are **Baker Gauges Private limited and**

Sr.	Process	Railway Workshops	OEM (Timken, NEI)	Remarks
		 Fig:- Baker Gauges air comparator module at RYPS Workshop. This does not measure taper in the cups.  Fig:- Dial bore gauge being used in Dahod Workshop.	 Fig:- Baker Gauges air Comparator at Timken to measure the dimensions. Taper is also measured along with ID and counter bore diameter.	**Mitutoyo(Japanese Make).** This will decrease the element of human error. The measurement of taper of cup is not a practice of IR Workshops. This practice should be **studied and incorporated in G81 Manual.**
8.	Assembly of cup and cone	Assembly of cup and cone is by placing the **right spacer** to **achieve the lateral play** as per G81 manual. It is checked manually by lateral play test bench with the use of dial bore gauge.  Fig:-Lateral play Test bench at Dahod Workshop	Assembly is done on a fully **automated PLC controlled line** where every component of CTRB is assembled and lateral play is checked digitally by automated equipment. This automation has been **locally developed by Timken. The rollers, naked cone, cage, cup and spacer are assembled collectively** in the same line each controlled through PLC.  Fig:- Automated Assembly line along with automatic lateral play checking. The data is digitally recorded.	The automated bench for lateral play is a **must** to achieve Centre of excellence status as it will primarily lead to reducing the failure rate of running bearings. Human error will get minimized. A standard specification can be fixed and procurement can be done in bulk.
9.	Grease filling, Pressing of grease seal	The grease filling is done automatically in most of the IR Workshops. After	The grease filling is done automatically. Seal wear ring is assembled with grease seal before	The assembly of seal wear ring and grease seal before pressing of grease

Sr.	Process	Railway Workshops	OEM (Timken, NEI)	Remarks
	and seal wear ring.	grease filling, the grease seal is pressed on the cup-cone assembly. Seal wear ring is pressed after grease seal has been fitted. This may lead to breakage of rubber lip of grease seal. This may also lead to wrong pressing of seal wear ring.  Fig:- Automatic grease filling machine at RYPS.	grease seal is pressed on to the cup cone assembly. This is done on a simple Poke Yoke fixture with taper on the top.  Fig:- Grease filling equipment at Timken	seal on cup-cone assembly is important as it prevents the damage of rubber lip of grease seal. This may result in minimization of failures due to grease seal breaking. This should be made a standard practice in all CTRB maintenance facilities of IR.
10.	Checking distance between pressed grease seal and cup outer ring.	Not checked in IR workshops.	Checked in Timken (OEM) by the use of digital dial bore gauge on a proper fixture. 	This ensures the correct fitment of grease seal on the bearing. If the distance is offset, the seal is not pressed properly. This should be made a necessary procedure and gauges can be standardized after consulting the supplier.

9. Conclusions:

The bearing repair facilities available on IR Workshops are based on basic component level inspection, repair and assembly activities. Over the period, higher standards of bearing repair and reconditioning have evolved mainly due to active involvement of Bearing OEMs with the aim to achieve higher, reliable and consistent bearing performance. However it requires additional specialised machinery, repair process and highly specialised manpower.

There are three major activities which are solely performed by OEMs namely,

a) Grinding of Cup, Cone and Rollers
b) Phosphate Coating of Steel part
c) Polishing

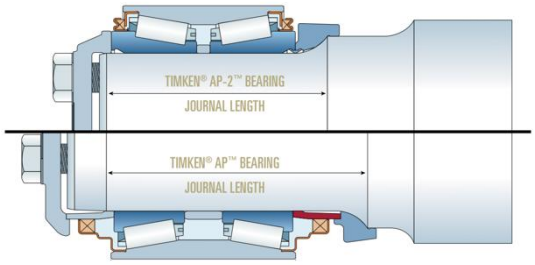
These additional activities help to reduce failure of bearing components and in turn improve life of bearing but it needs additional infrastructure.

10. Recommendation :

10.1 As mentioned in Para 8 above, some of the common activities of CTRB repair available in Railway Workshops and that with OEM refurbishment facilities can be upgraded as OEMs have better facilities. This will help to improve the quality of repair and CTRB performance in service.

10.2 TIMKEN have developed shorter length bearings with following benefits claimed.

TIMKEN AP-2™ BEARING



To meet the growing challenges of increased loads and speeds, we developed the Timken® AP-2™ bearing for freight cars. Based on the design of the AP bearing, we engineered the AP-2 bearing to minimize journal axle flexure and fretting wear. When integrated with Timken premium seals and polymer cages, AP-2 bearings can offer significant energy savings.

As a design improvement, this design of bearing can be considered to be introduced on IR wagons which may help in reduced fretting corrosion of CRTBs and lower hauling energy requirements.

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